its arrangement, in the satisfactory manner in which physical phenomena are described and explained, and in its general accuracy. Their 'Elementary geography' is equally well adapted to infantile minds. The illustrations of both editions are well selected, and are beautifully executed. The maps are modern, and are well adapted to the purposes of instruction. On the whole, the orography — the element with with which map-makers have the most difficulty — is fairly, and in some regions excellently, expressed. The registering of the colors on the maps can be very much improved.

— Dr. Daniel G. Brinton of Philadelphia has been announced as laureate of the Société américaine de France for 1885, and has been awarded the medal of the society for his works on the aboriginal languages and mythology of America.

— At about 10.12 P.M. on Dec. 10, a sharp shock of earthquake was felt in Victoria, B.C. It resembled the rapid roll of a heavily laden truck along a paved street. The vibration lasted from ten to fifteen seconds. At New Westminster the shock was felt at precisely the same time, but lasted about forty seconds.

— An atlas of Japan, in seven sheets, is announced by Justus Perthes. Each sheet will be on a scale of 1 : 1,000,000, and the atlas will be accompanied by a sketch-map on a scale of 1 : 7,500,000. Four of the sheets have already appeared, and the others will be issued during the coming year.

— The new balloon constructed by the Meudon aëronauts will be directed, says *Nature*, by a steam-engine, as advocated by M. Henry Giffard. Electricity will be quite given up, owing to its want of power for continuous action. From the reports to be published in the next number of the *Comptes rendus*, it appears that a velocity of six metres per second was obtained.

— Mr. Gaurel, at whose sole expense the late expedition to the Kara Sea, under Lieutenant Hovgaard, was undertaken, intends, provided his enterprise be seconded by the government, to send his steamer Dymphna next summer on an expedition, under an officer of the Danish royal navy, to the east coast of Greenland to explore and lay down the coast-line between 66°.08, the farthest northward point attained by Captain Hohn's expedition, and 70°.

— On examination of the extensive series of stellar photographs obtained at the Harvard college observatory, it appears that on Nov. 7, 1885, a photograph was taken of the region in which the new star is now visible. The star does not appear upon this photograph, which shows that at that time it must have been at least half a magnitude fainter than at present.

LETTERS TO THE EDITOR.

What has the coast survey done for science?

The contributions of the coast survey to general scientific knowledge in America may be said to begin with the year 1844, when Prof. Alexander Dallas Bache succeeded to the superintendency, on the death of Mr. Hassler, in December, 1843.

Mr. Hassler had given all the active energies of his life to a successful inauguration of a work of which few but himself realized the extent, or had any idea of what was implied in a 'survey of the coast of the United States;' and he came from Europe to this country at the beginning of the present century, when our country was still barely recognized among nations, and its few and ablest men were too much engaged in meeting and solving the practical problems of existence for the nation generally, and for themselves individually.

The number of men at that time who had made their mark as original investigators and thinkers in the different branches of astronomy, chemistry, mathematics, and physics, were so few that they might be counted upon the fingers. A few of the associates of the illustrious Franklin, among them Rittenhouse, Ellicott, and some others of the American philosophical society of Philadelphia, were joined by others from abroad — men like Priestly and Gallatin — in correspondence with men of like pursuits in England, France, and Germany, and were slowly and quietly laying the foundation for the building-up of a spirit of scholarship and physical inquiry, which rapidly developed after peace came finally to the country, in 1845, producing such men as Bowditch, Nicollet, and many others.

Mr. Hassler came to this country accredited as a man of learning and ability by the French academy. Being a native of Switzerland, he became intimate with his countryman, the eminent statesman Albert Gallatin, who was at that time secretary of the treasury under President Jefferson. The President had himself been given greatly to philosophic studies, and had, while resident in France, been the companion and friend of many of the most eminent men of science in that country.

It was through Mr. Gallatin's active and powerful aid that the idea originated by Mr. Hassler, of a great general 'survey of the coast of the United States,' was brought to Mr. Jefferson's notice, and his powerful aid secured in obtaining the passage of the act of February, 1807, which is still the legal basis of its existence.

Obstacles of various sorts arose in the way of carrying the act into execution. Chief among them was the war of 1812–15 and its consequent debt, crippling the means of the nation. Started in 1816, it was shortly after transferred to the navy, where it languished until, in 1834, it was re-transferred to the treasury department, where it has ever since remained.

The principle of organization adopted (and still adhered to, so far as practicable) was carried forward by Mr. Hassler under many difficulties, which were brought to the notice of congress, and resulted in the reference of the whole subject to a committee of

investigation, of which the late Hon. Caleb Cushing was one of the principal members. The result was "legislation creating a mixed board, from the coast survey, army, and navy, which adopted the plan of re-organization," in 1843. This, on approval of President John Tyler, had the force of law, and under it the survey has been conducted. The following extract from the report of the superintendent for the year 1849 describes the practical working of the system: —

"The re-organization of the coast survey, under legislative authority," in 1843, embodied all the experience obtained up to that date, both of trials which had succeeded, and of others which had failed: it confirmed and gave the force of law to the union in our corps, which has gradually grown up, of civilians, officers of the army, and officers of the navy, serving under a neutral department, under which alone they could be united; namely, that having control of matters relating to commerce and navigation. It is easy to see, that, without a permanent (civil) nucleus for such a work, the objects and aims must be wavering and unsteady, the methods wanting in uniformity from year to year and from party to party, and the results heterogeneous in kind and in form. Confusion and waste would result from such an organization, and the survey would in time be abandoned. The scientific parts of such a work require diligent study and devotion to mathematical and physical science, to grasp them in their various bearings; and it is not too much to say, that, unless such a work came up to the demands of science and the scientific men of the country, it could not long stand. That the theoretical knowledge acquired at the military academy should be reduced to practice in the survey by those officers of the army who have an inclination to similar pursuits, to its advantage as well as their own, will readily be seen; and, up to the point where details would interfere with the duties of the arm to which the officer belongs, congress has conferred upon the work a right to seek his services. The war department judges whether they can be properly granted or not.

"The law of 1843 very properly limited the services of the officers of the navy to the hydrographic parts of the work, — the portions which have a professional bearing, and towards which the inclination of a nautical man may turn with professional pride. Experience has fully shown the advantages of this organization in general. The tendency resulting from the variable elements (the army and navy) is nevertheless, at times, to lessen the results produced by the necessity for turning aside from actual work to give instruction, and from the loss of the experience acquired at the expense of the survey by the removal of officers — caused, no doubt, by the exigencies of their proper service, and yet reacting severely upon the survey. The experience and knowledge of Humphreys, Johnston, and Prince, of the army, and of Davis, Patterson, and Porter, of the navy, cannot readily be replaced: a detail may be filled, but the knowledge immediately available is not supplied."

Mr. Hassler died in December, 1843, just as this system went into operation. He had never realized the enormous advance which the country had made in every department of industry and learning in the thirty-six years which had gone by since the passage of the law of 1807. To his mind we had then to look abroad not only for all appliances for scientific research, but also for the men to use them. The late Mr. Thomas McDonnell, so long in the coast survey, informed me, that, so late as 1836 and 1837, he was the only man in Mr. Hassler's party who habitually spoke the English language. But in that period Bowditch had risen to the zenith of his reputation; men like Peirce, Henry, Bache, Walker, Morse, and many others, had come forward, and placed American science upon the enduring basis which has ever since been maintained and extended.

From among these eminent men, Professor Bache was selected, by almost unanimous consent of the learning of the country, to succeed Mr. Hassler at the head of a work then recognized as the greatest, as it was almost the only, scientific work of the country. The pressure upon President Tyler for his appointment was so great that he was obliged to yield to it, although he was opposed by the then secretary of the treasury, Hon. John C. Spencer, who preferred another person, but who soon recognized the remarkable fitness for his position shown by the new superintendent, and in less than six months became his firm friend and supporter.

From this time forward the work of the coast survey was rapidly extended; its increased usefulness was recognized by congress by steadily increasing appropriations, as the work was extended to all parts of the coast. Between 1844 and 1849, or in the short period of five years, the extent of the coast line of the United States was doubled by the addition of Texas, and the Pacific coast from San Diego to Vancouver. But such was the elasticity of the wise method of organization formulated in 1843, that the work expanded to meet the calls upon it, and surveying parties were upon the shores of Texas in 1847, and in California in 1849. The history of the work from that time forward, and during and since the civil war, has been one of which every man connected with it has reason to be proud. It has been foremost in every matter connected with the interests it has had in charge. It has won the approbation, freely and officially expressed, of every enlightened government of the civilized world.

In 1872, for the first time, its work was extended to the interior, and it was recognized by law as the 'coast and geodetic survey.' Other scientific works have been authorized, and some of them have appeared to come in conflict with the duties assigned to it, and seeming to belong to it. With these it has sought or shown no conflict, but has freely rendered to them every possible aid in its power. This is not the place to discuss or further allude to these points. The historical *resume* here given, of the early inception and progress of the work under its most renowned chief, has been necessary to a proper understanding of the matters now to be brought forward in answer to the question asked me, 'What has the coast survey done for science?' to which I now attempt a reply.

Longitude.

In 1844 the difference of longitude between any point in Europe and any point on this continent was uncertain. Then, as now, the meridian of the Royal astronomical observatory at Greenwich, England, was the reference-point from which longitude was reckoned by English-speaking nations.

One of the first matters taken up by Professor Bache was to obtain a correct difference of longitude between Greenwich and some central point in the United States connected with the survey of the coast.

The services of the best American astronomers were enlisted in collecting and reducing all astronomical observations bearing on the matter. Measures were at once taken for obtaining a different and better class of results by transportation of chronometers on the Cunard steamers between Liverpool and Boston. This method so far superseded others, that it led to the final adoption of the observatory at Cambridge, Mass., as the point of reference for all coast-survey longitudes. Its director, Mr. W. C. Bond, also had charge of all chronometers used in the Cunard steamers.

While this was in progress, other observers at Philadelphia and elsewhere made and reduced observations of occultations and moon-culminations for the same purpose. These observers did not belong to the survey, but were paid small sums for copies of their observations and reductions. By this means the coast survey, under its enlightened head, assisted in bringing forward many men who have since become well known, but who were held back for lack of pecuniary means and instruments, both of which were supplied by the coast survey.

The Morse telegraph had just come into use in 1844. Its application to the purpose of determinations of exact differences of longitude was suggested by Professor Bache to the famous inventor before even the success of the telegraph itself had been commonly accepted as secure. Experiments were made in 1845 and 1846 as soon as lines were established, and in 1846 the first recorded observations were made between Washington and Philadelphia. The ease and precision of the method attracted the attention of all American astronomers, and all attempts at improving it were fostered by Professor Bache. Each year brought improvements in the methods of observing and recording, and greater precision and refinement in the character of the results. First came the disk of Professor Locke of Cincinnati; next that was improved upon, and the clock-beats by telegraph rendered automatic by Prof. O. M. Mitchell, by which an astronomical clock in Cincinnati was made to beat and record its time both audibly and graphically in other and many distant places at the same moment. Finally the invention and perfecting of the 'chronograph' brought the whole to its present state of perfection. As soon as the Atlantic cable became a success, in 1866, it was at once employed by the coast survey to obtain a precise difference of longitude from Greenwich, and this was repeated at three different periods and by different cables and observers in 1870 and in 1872, with an extreme discrepancy of only five-hundredths of a second of time, leaving nothing further to be desired. In 1852, on the death of Assistant S. C. Walker, Prof. B. A. Gould succeeded him as assistant in charge of telegraphic longitudes at intervals until his resignation in 1868. During this time the development of the method was carried forward by him with his usual zeal and energy. His last great work was the inception and execution of the first telegraphic determination of longitude from Greenwich through the cable, then just laid, in the fall and winter of 1866. The difficulties then encountered and overcome (much greater than in any subsequent expedition) are fully detailed in his elaborate report, printed as appendix No. 6 to the coast-survey report for 1867.

There have been printed between 1846 and 1884, by the coast survey, 26 reports on astronomical methods of determining longitude, 8 reports on chronometric methods, and 30 on telegraphic methods; in all, 64 papers, by Peirce, Walker, Bond, Gould, and Hilgard, being a larger mass of contributions to our knowledge of this important practical and scientific question than has been made by any other one nation within the same period.

This application of the telegraph to the determination of one of the two most important geographical problems known to science has completely revolutionized all previously known methods. It is in use all over the civilized world, and is everywhere known as 'the American method.' It was begun, and has been brought to its present state of perfection, by the coast survey.

The Gulf Stream.

The exploration of this 'river in the ocean' was commenced in 1844, and has been continued ever since under coast-survey direction. Apparatus was used for obtaining temperatures at such depths as could be obtained. In 1846 the separation of the Gulf Stream into two branches was discovered, and was dearly paid for by the loss of a brilliant officer of the navy, brother of Professor Bache, who was swept from the deck of the vessel he commanded in a storm off the coast of North Carolina. The surveys have been kept up and continued, as means have been afforded, from that time to the present.

The ingenuity and skill of the naval officers who have been at different times attached to the survey have resulted in improvements of means and methods, until depths exceeding five miles have been reached; and it has been satisfactorily shown, that, underneath the warm surface-water of the Gulf of Mexico and the Gulf Stream, the temperature of the water steadily diminishes until it is nearly ice-cold at the bottom. The inventive genius of Commanders Bartlett and Sigsbee, U.S.N., while engaged in this duty under Superintendent Patterson, has left little for their successors to do but to follow in the way they have marked out.

Early in this work, or before 1850, the enlightened and liberal view taken by Superintendent Bache, of his obligations to science, led him to take up an apparently different department of science in authorizing dredging to be executed at great depths, that the nature of the inhabitants of the deep sea might be ascertained. This gave to America as a citizen one of the most eminent naturalists of the world. The late Prof. Louis Agassiz has left on record his statement that his determination to become an American citizen was decided on in consequence of the enlightened liberality of Prof. A. D. Bache, superintendent of the U. S. coast survey, in offering him the facilities afforded by the surveying parties and vessels of the work for conducting his investigations upon the Atlantic and Gulf coasts. The magnificent models of the bottom of the ocean in the Bay of North America and the Gulf of Mexico, made under direction of Professor Hilgard, and that of the Caribbean Sea by Commander Bartlett, U.S.N., are results of the long-continued, earnest, and effective labors of the various parties of the coast survey, and the ingenious efforts of the officers of the navy, on coast-survey service, who commanded them.

Tides and currents.

Systematic observations of tides and currents were begun in 1844; and in 1845 the very difficult problem of tides in the Gulf of Mexico, where only one tide

occurs in each twenty-four hours, was attacked. Staff-gauges were first used, but were shortly supplemented by an ingenious self-registering gauge, invented by Mr. Joseph Saxton, of the weights and measures office, by which a continuous automatic record of the rise and fall, with effects of winds and storms, was kept up. These were gradually multiplied by similar instruments at carefully selected points along the coast, until, in 1854, sufficient data had been collected and reduced to form a theory on which was based tables of predicted tides for every day in the year, and for all principal ports upon the Atlantic and Gulf coasts. This contribution of the coast survey to the practical necessities of navigators has been continued and gradually improved up to the present day, and large editions of these little books are yearly printed and eagerly sought for. Similar tables for the western coast, founded on similar observed data, were first published in 1870, and are also continued.

A very considerable contribution to science occurred in 1883, when the tide-gauges of the coast survey at San Francisco, Alaska, and Honolulu, all indicated upon their automatic record the effect of the great earthquake at Krakatoa, in the Straits of Sunda, full one-quarter of the circumference of the globe from the nearest tide-gauge. These earthquake-waves, greatest at Honolulu, continued to impress themselves upon the records for between four and five days. Photographic copies were sent to the Royal society at London by their request.

Another contribution to science in this department has been the invention and daily use, in the coast-survey office, of a tide-predicting machine, which, being set to represent certain elements obtained by not less than a yearly observation at any place, will, by simply turning a crank, predict the times and heights of future tides at that place for the ensuing year. This invention is by Prof. William Ferrel, formerly of the coast survey, and now of the signal service.

Physical hydrography.

Tidal currents, and the laws governing them, have been studied, and the best methods of so controlling them as to aid navigation by deepening channels have been applied in all parts of the Atlantic and Gulf coasts; the basis of action being the coast-survey maps, and the organization of each commission appointed to advise the best action being precisely that of the coast survey. Such commissions have acted, with the most useful effect, in Portland, Boston, Providence, New York, Philadelphia, Wilmington, N.C., Charleston, Savannah, and other places. In all cases the commission has consisted of one engineer officer of the army, one naval officer, and one coast-survey officer. Usually the naval officer has been one who had several years of experience in hydrography upon the coast survey.

Prof. Henry Mitchell, an assistant in the coast survey, has made physical hydrography his special study, and has become one of the recognized authorities upon the subject in this country. He is, and has been since its formation, a prominent member of the Mississippi River commission. Of the one hundred and seventeen publications by the coast survey on the subject of physical hydrography between 1845 and 1883, twenty-seven are by Professor Mitchell, and all have a direct bearing upon the best methods of improving the commerce and navigation of the principal ports and navigable thoroughfares of the Atlantic and Gulf coasts.

Magnetic observations.

In the early surveys of this country, the compass, with its magnetic needle, has been the principal instrument used. It still continues to be largely used, especially in new settlements, and portions of the country where land is of small value. In more populous portions, where land has become valuable, it is being steadily discarded for instruments of greater precision. As a consequence of its great use, observations to determine the general and local magnetic variation had been made in many places from the earliest period of the country's settlement. As our knowledge of the subject increased, and the laws governing the all-pervading magnetic principle came to be better understood, observations not only for magnetic variation from the true north were increased, but apparatus was invented and largely used for observing the two components of the magnetic force, and obtaining the total intensity with which it acts upon a freely suspended magnet in any locality.

Observations of this character were commenced in the coast survey in 1833, and have been kept up ever since, being vigorously pursued since 1844. Small amounts were also paid to outside observers, and in some cases instruments have been loaned on condition of furnishing copies of their observations. Since Professor Bache's death, this important department of coast-survey scientific work has been in the hands of Assistant C. A. Schott, who has, with indefatigable labor, made it specially his own. He has collected and digested all detached observations from every quarter of North America. The tables and maps prepared under his direction, and published by the coast survey, have been and are more largely called for than any other publications; and the expressions of thanks for and appreciation of the valuable practical aid they have given, have been received from engineers and surveyors throughout the entire country. Seventy-two publications have been made by the coast survey on terrestrial magnetism, of which fifteen are by Professor Bache, and forty by Assistant Schott.

Astronomy as applied to geodetic surveys.

When Professor Bache became superintendent of the coast survey, in 1844, it possessed no instrument for precise determination of latitude superior to a sextant. Lieut. Thomas J. Lee and the writer spent a large portion of the season of 1844 in vain endeavors to obtain reliable results from the larger instruments in its possession, which still remain in the archives to mark the progress made in this branch of 'practical astronomy.' Only one small portable transit instrument for observing time belonged to the survey. As rapidly as possible instruments of a higher order were introduced, and better methods of observation and reduction began. The zenith telescope was introduced. This instrument, invented for a different purpose, had been ingeniously applied by Capt. Andrew Talcott, Corps of engineers, U.S.A., to a method of determining latitude, of so delicate, precise, and simple a character, as to leave nothing to be desired in these respects. Just at that time the British association for the advancement of science had published their catalogue of places of over seven thousand stars, chiefly in the northern hemisphere,

which made Captain Talcott's method easy of application for field use at geodetic stations. Professor Chauvenet says of the zenith telescope, —

"The method of finding the latitude by this instrument, now known as Talcott's method, is one of the most valuable improvements in practical astronomy of recent years, surpassing all previous known methods (not excepting that of Bessel by prime vertical transits) both in simplicity and accuracy."

Soon it was found that observations by Talcott's method, with the zenith telescope, were superior in precision to the places of the stars observed as given in the catalogue. Hence arose a demand for better star-places; and the observatories of the country were called upon by the coast survey to furnish them, the coast survey paying for the labor involved in observation and reduction. The directors of the observatories, finding their instruments and means insufficient for the desired results, applied themselves to procure better; and thus again the coast survey, by the stimulus it gave to astronomical means and methods, added another to its list of aids given to the advancement of American science. As a consequence, in a large part due to this cause and to those mentioned in what has been said respecting telegraphic determinations of longitude, we have at present catalogues of star-places of a degree of precision of the highest order.

In 1867, Assistant George Davidson invented and added to our means an ingeniously contrived instrument for observing both latitude by the Talcott method, and local time as usual with a transit instrument, by one and the same instrument. This 'combination instrument' is now largely and successfully used.

Geodesy.

All contributions by the coast survey to science in this department must, of necessity, be practical in their character, since the principles involved in the application of all geodetic methods are as old as Euclid.

Improvement in accuracy of geodetic instruments of every class, and especially in improving their precision while diminishing their size and weight, has been marked and steady from 1844 to the present time. More precise observations are now obtained with a theodolite having a graduated circle of twelve inches diameter than could be had in 1844 with instruments having circles of twenty-four and thirty inches diameter. When it is considered that these instruments are transported to the highest summits of North America, often upon the backs of mules, it will be perceived what a gain to precise scientific observation is obtained by the diminishing of weight.

The substitution of the observation of directions for that of angles is another gain to science. The change of the problem to be ascertained by observation, from 'What is the most probable measure of a certain angle?' to 'What is the most probable direction of a certain line?' has added greatly to ease of observation, and precision in results.

Methods of determining azimuth, or the angle made by any geodetic line with the meridian of the place of observation, have been simplified and multiplied, and increase of precision obtained, with less labor and in less time.

Wherever it had become necessary to use artificial elevations for geodetic observations, it had been usual in Europe, India, and America, to use repeating theodolites which only required temporary stability, not usually exceeding a couple of minutes at a time. For important primary stations, brick towers were erected; or, if wooden towers were used, they were carefully enclosed to protect them from the sun's action. But in 1868, Professor Peirce, then superintendent of the coast survey, authorized the use of open wooden insulated tripods for supporting the larger direction instruments of the coast survey.

The legs of the tripods were exposed to the full action of the sun's rays, while shaded by light cotton screens from the force of the wind. The motion of the wooden tripod caused by the action of the sun's rays was eliminated from the result by the method of observation adopted. Since that period the largest and most delicate theodolites have been successfully used upon cheap wooden structures in many parts of the country, and money and time saved with no falling-off in precision.

Within the past ten years the old methods in vogue a century ago, of observing upon intensified lights at night, have been renewed, using both magnesium and coal-oil reflector-lamps, and much time has been saved by adding to the number of hours when observation was possible. The precision of the work has also gained by night observation.

Topographical methods have also been improved. The use of the plane-table has been extended, and this unrivalled method of executing precise maps, by making and correcting them upon the ground itself, is now regularly taught in some of our scientific schools, as are other coast-survey methods of observation, reduction, and computation. In every institution of learning in this country, at Cambridge, New Haven, New York, Ithaca, the coast survey has left its impress, and everywhere for good.

The coast survey is as well able to continue its course now as it ever has been. Its officers are as able and zealous as they were twenty years ago. Its form of organization has proved itself well adapted to its needs, and, with some essential changes to cause it to conform more closely to the changed external conditions, it may do the country thorough and vigorous service. It is to be devoutly hoped that the opportunity may be given it to prove what it is made of, and that its force may be more concentrated, instead of being broken up and scattered.

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An old work on political economy.

The last numbers of *Science* brought to my memory the time of 1842, when I studied in Paris, and had, by the request of my father, professor of political economy, to procure for him a large number of books and tracts on political economy. Some of them were very rare, even in the libraries, and I had to content myself with making out a very full and detailed account of their contents. Among them was, 'Traité de l'oeconomie politique, dedié au roi,' etc., by Antoine de Montchretien, seiur de Vateville à Rouen, 1615 pet. 4°. The book was only to be found in the Bibliotheque Mazarine and St. Genieve, not in the Royal library. It was considered very rare The book is interesting, as the phrase 'political economy' is first used in it, and its author considered to be its founder. The book is very interesting, praises Tully and his maxims, and is decidedly strong for protection. There are also to be found in it a number of curious